these in steps exhibited in several successive Tables, results are found for the magnetic disturbance in the three directions, longitudinal, transversal, and vertical; and these are compared with the terrestrial forces in the same directions. The principal results are, that the transversal and vertical parts of terrestrial magnetism are absolutely neutralized, and the terrestrial longitudinal force is diminished by about one fourth part.

An anomaly presented itself in the results for the station at the middle of the Anglesey Wate-tube, which induced the author to inquire of Edwin Clark, Esq. (the actual Superintendent of the construction of the bridges), whether any peculiarity of material could explain it. Mr. Clark immediately remarked that this was the tube which, in the act of raising the sections of the tube, sustained a fall of several inches, undoubtedly straining the tube very greatly. It appears almost beyond doubt that this accident is the cause of the anomalous magnetic condition of that section of the tube. Mr. Clark remarks that it is an interesting fact, if established, that the result of an accident which occurred about a quarter of a century ago can still be traced in the magnetic condition of the tube.

The results in the Conway bridge, for transversal and vertical action, are in perfect agreement with those for the Britannia bridge; but the results for longitudinal disturbance do not present the same agreement. The Conway bridge, however, is nearly at right angles to the magnetic meridian; and it appears probable that its magnetical state depends on the circumstances of its construction, when its Holyhead end was in a direction about 48° 50′ west of north, in which position it would receive much magnetism, which the forces subsequently acting on it could not remove.

II. "On the Organization of the Fossil Plants of the Coal-measures.—Part IV. *Dictyoxylon, Lyginodendron,* and *Heterangium.*" By W. C. Williamson, F.R.S., Professor of Natural History in Owens College, Manchester. Received December 4, 1872.

(Abstract.)

In 1866 Mr. Binney gave the name of *Dadoxylon Oldhamium* to a fossil stem of a plant from the Lower Coal-measures of Lancashire, believing it to belong to the same class of Gymnospermous Exogens as the *Pinites* of Witham and the *Dadoxylon* of Endlicher. In 1869 the author pointed out that the reticulated markings upon the surface of its vessels were modifications of the spiral fibre of fibro-vascular tissue, and not the disks of what is often designated glandular fibre. He consequently separated the plant from the Dadoxylons under the name of *Dictyoxylon Oldhamium*. At the Edinburgh Meeting of the British Association in 1871 he gave a brief account of the structure of this plant, as also of what appeared to be a second species from the Lower Coal-measures of Burntisland in Fife-

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shire, which he called *D. Grievii*, after its discoverer, D. Grieve, Esq. A detailed exposition of the organization of these two plants is given in the memoir.

Dictyoxylon Oldhamium.—This was a stem composed of the three divisions of pith, wood, and bark. The pith consisted of regular parenchyma without divisions or cavities of any kind. In very young plants it was surrounded by an irregular ring or medullary cylinder of reticulated vessels, not arranged in radiating laminæ. This cylinder broke up at an early period into several detached vascular bundles, which, as the stem enlarged, became widely separated from each other, the intervening space being occupied by medullary parenchyma. But before this change was completed, the true ligneous zone appeared as a thin ring of vessels arranged in radiating vertical laminæ, separated from each other by large and conspicuous medullary rays, composed of mural cellular tissue. Additions were made to the exterior surface of this zone by the agency of a delicate cellular layer of cells, which constituted the innermost layer of the bark. These additions demonstrate their exogenous nature in several specimens in which the vessels of the outermost zone have not attained to half their normal size, resembling in this respect some of the Lepidodendroid plants described in the author's last memoir (Part III.). Through these successive exogenous growths the vascular axis of the stem ultimately became arborescent. One specimen is described in which such a vascular axis, though imperfect and waterworn, is fully six inches in diameter, independent of the bark; other specimens have been obtained intermediate in size between the above example and the small stems more usually met with. The vascular laminæ increased in thickness as they proceeded from within outwards, and then subdivided, in the ordinary exogenous manner, through the intercalation of new medullary rays. These rays are remarkable for the great vertical range of each one, as well as for the large number of cells which enter into their composition. In tangential sections they appear as elongated lenticular masses of parenchyma.

The Bark.—This organ is separable into three, if not four layers. The innermost one is a delicate parenchyma closely investing the ligneous zone, its cells being continuous with those of the medullary rays. At its outer surface this tissue passes gradually into another parenchymatous layer of greater thickness than the inner one. Both of them have patches of dark-coloured cells scattered through their tissues. But the most remarkable part of the bark is the third or prosenchymatous layer, which presents very different features according to the aspect in which it is regarded. In the transverse section it consists of radiating bands of parenchyma alternating with narrower and very dark-coloured ones of woody prosenchyma, the latter looking very like the Roman numerals upon the face of a clock. Tangential sections show that the black bands are fibrous laminæ, which pursue an undulatory course as they ascend

through the stem, and which, as they alternately approach and recede from one another, divide this part of the bark into a series of lenticular or rhomboidal areas, occupied by various forms of parenchyma. No vascular bundles enter these areolæ; hence they are something altogether different from the leaf-scars of the *Lepidodendra*. Externally to this prosenchymatous layer some specimens exhibit detached traces of a very thin external layer of parenchyma, apparently derived from the cells of the rhomboidal areolæ, which have extended beyond the fibrous laminæ and spread themselves over the surface of the bark as a continuous layer; but this condition appears to be confined to very young stems.

Vascular bundles of large size ascend vertically through the two inner parenchymatous layers of the bark. In some instances each of these bundles exhibits, in the transverse section, an oval outline, with faint traces of a vertical division into two parts. But ordinarily the two halves of the bundle have separated, forming two distinct bundles, which are some distance apart. They exhibit little or no tendency to diverge from the ligneous cylinder as they ascend, and in some instances actually become incorporated with it. It is remarkable that the position of each of these double bundles, at the *exterior* of the ligneous zone, corresponds with the spaces intervening between the detached masses of the medullary cylinder *within* it, as if the former were designed to act as buttresses strengthening these weaker points in the vascular axis. It not unfrequently happens that exogenous additions are made to such of these bundles as are encompassed by the innermost layer of the bark, in the shape of a few radiating laminæ of vessels developed on their outer or peripheral surfaces.

One specimen of the vascular axis is, as already mentioned, so large as to demonstrate that the plant became arborescent.

Though *Dictyoxylon* was not a dichotomizing plant, like *Lepidodendron*, it gave off lateral bundles of vessels. Some of these are simple bundles, consisting of numerous vessels intermingled with some cellular tissue. Others have this central bundle invested by a thin ring of radiating laminæ with intervening medullary rays; this exogenous ring sometimes becomes developed into a relatively large and distinct woody zone, like that of the parent axis. The vessels of these lateral growths appear to be wholly derived from the radiating woody zone.

A second form of lateral appendage appears to spring from the medullary rays, and consists of a cylindrical mass of reticulated cells, which are chiefly prosenchymatous, but of an elongated type. It is suggested that this structure may have been prolonged into an adventitious root.

The structure of the central or medullary vascular axis of the former of these two kinds of lateral appendages seems to indicate that the history of the development of the medullary vascular cylinder in these plants corresponds with what the author described in his preceding memoir (Part III.) as taking place in the similar parts of the *Lepidodendra*, viz. that

some of the cells of the central part of the axis underwent rapid fission, and thus developed a distinct cellular medulla, which forced the medullary vessels outwards where at first they constituted a ring, but which ring soon broke up into the detached vascular masses already referred to as adhering to the inner surface of the exogenous zones.

The enlargement of the exogenous woody cylinder by the peripheral intercalation of new radiating vascular laminæ, and the repeated subdivision of these laminæ by a corresponding intercalation of new medullary rays, demonstrates the close resemblance between the growth of the ligneous zone in these plants and that of ordinary exogenous stems. A fine series of specimens collected by the Rev. H. Higgins, of Rainhill, near Liverpool, and which exhibit various modifications of the type figured by the late Mr. Gourlie under the name of *Lyginodendron Landsburghii*, are shown to be merely casts of the exterior surface of the bark of some species of *Dictyoxylon*. They may actually belong to *D. Oldhamium*; but this is not yet proven.

Dictyoxylon Grievii.—This plant has many points of affinity with *D. Oldhamium*; nevertheless it has very distinct features of its own. Its central or medullary axis is very large in proportion to the thickness of its exogenous ring; the former consists of cellular parenchyma, throughout which are scattered numerous bundles of exquisitely reticulated vessels unprovided with any special sheaths. The largest vessels are nearest the centre of the axis, the peripheral ones becoming smaller, more numerous, and grouped in more continuous masses. Immediately surrounding this vasculo-cellular axis is a thin ring of similar vessels, but arranged in radiating laminæ, separated by well-defined medullary rays. This zone is generally of unequal thickness on opposite sides of the plant, and contains some barred vessels amongst its reticulated ones; the medullary rays are composed of mural cells.

The bark consists of three very distinct layers. The innermost one is very thin, consisting of delicate parenchyma, but which nevertheless has formed a very clearly defined flexible layer; outside this is a thick stratum of coarser but regular parenchyma subdivided in the transverse section into vaguely defined areas by thick wavy lines of condensed cells. The peripheral outline of this zone is very irregular, frequently projecting outwards in large angular masses. It is bounded by a prosenchymatous external layer, which is a dwarfed representative of the corresponding one of *D. Oldhamium*. In the transverse section it exhibits dark radiating bands of fibres, longitudinally disposed, alternating with similar bands of parenchyma; but it differs from *D. Oldhamium* in the narrowness of the latter, and consequently in the more linear form of the cellular areolæ of the outer bark. In longitudinal sections of the bark its innermost layer appears as in transverse ones. The middle parenchyma, on the other hand, exhibits remarkable differences from its aspect in the transverse section: its cells are arranged in vertical columns; but these are inter-

sected at intervals of nearly $\frac{1}{50}$ of an inch by horizontal and parallel bands of very dark-coloured cells of a special nature.

Seven or eight large vasculo-cellular bundles exist in each transverse section of the bark. Some of these are located within the exogenous layer of the wood, being obviously detached portions of the cells and vessels of the medullary axis; others occur, in various specimens, at every point between the wood and the outer bark. The author finds that these bundles remained for a time in the immediate neighbourhood of the innermost bark, but that they successively became detached and moved more rapidly outwards, until each one emerged at the periphery of the bark in one of the prominent angles of the latter, already referred to; when one bundle has thus reached the periphery, another begins to follow the same centrifugal course. The inference is, that these are foliar bundles, supplying large leaves or petioles, sparsely grouped round the stem. A single example of a similar centrifugal bundle was found in *D. Oldhamium*. The seemingly irregular projections of the bark of *D. Grievii* thus appear to represent angular petioles, and are not the result of merely accidental pressures. A second kind of cylindrical bundle is noticed, consisting of reticulated prosenchymatous cells. It is connected at its central extremity with the medullary parenchyma, whilst its peripheral end passes outwards through the bark. It appears to have had the same character as the similar one of *D. Oldhamium*, having probably been an adventitious root-bundle.

Somewhat triangular twigs or petioles of the above plant are numerous. They consist of a single vascular bundle, located excentrically near the cordate base of the triangular transverse section, and surrounded by the three bark-layers seen in the older stems. The structure of these layers, as seen in the longitudinal sections, is identical with, though less complex than, that of the matured stems; but no cortical vascular bundles are seen in them.

Having identified his *Dictyoxylon Oldhamium* with the older genus *Lyginodendron*, the author abandons his own generic name, and proposes that the plant shall henceforth be designated *Lyginodendron Oldhamium*. He establishes in the same way the generic identity of *Dictyoxylon Grievii* with the *Heterangium* of Corda; hence that plant must now take the name of *Heterangium Grievii*. Whilst having no doubt that the above were two Cryptogamic plants, it appears impossible for the present to determine to what class of Cryptogams they belong. Many of their features indicate Lycopodiaceous affinities; but this point can scarcely be determined until the actual fronds are discovered. This has not yet been done. The *Lyginodendron* is from the horizon of the Ganister beds of Lancashire and Yorkshire; the Burntisland deposit belongs to the middle portion of the calciferous sandstones of the Burdiehouse Carboniferous strata.